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Specification of the Interface between the Level-1 Calorimeter Trigger and the Level-1 Central Trigger Processor

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Abstract

This document specifies the interface between the Level-1 Calorimeter Trigger and the Level-1 Central Trigger Processor in terms of physical links, signals, data format and configuration data.

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1	0	13 NOV 2002	First version in EDMS.
1	1	14 NOV 2003	Changed number of bits of XE to 4, and of JE to 3. Fixed inconsistencies in tables 3 and 4, for XE and JE.
1	2	10 AUG 2004	Changed energy hits to be sent as hit map, and not as encoded value.
1	3	25 AUG 2004	Changed numbering of trigger thresholds, preference of connector and wording in Section 5.
1	4	3 SEP 2004	Clarified pin-out of trigger cables.
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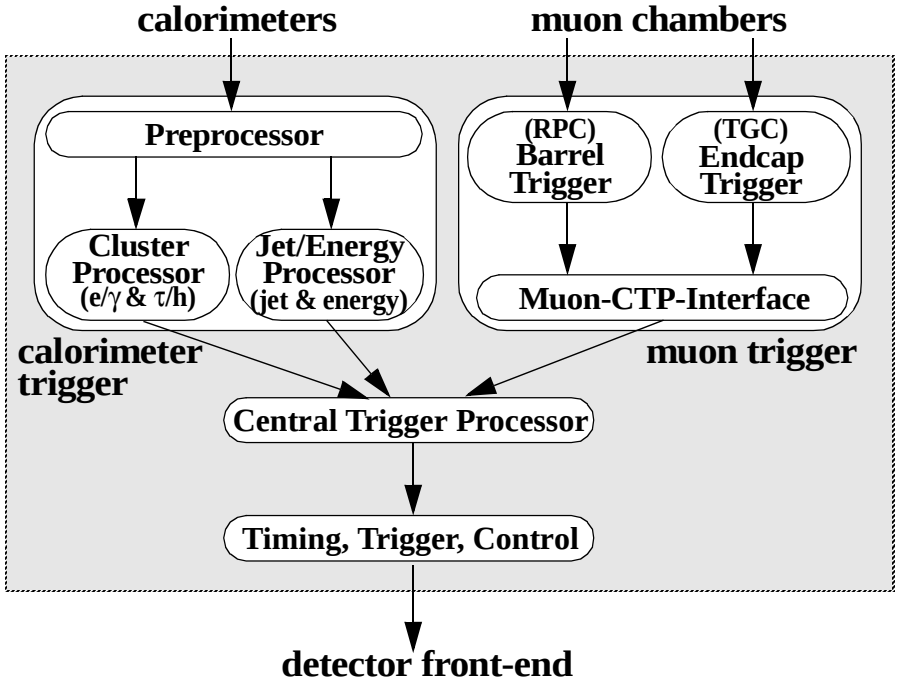
2	0	31 JAN 2005	Modifications after L1 Calo CMM Final Design Review.
2	1	18 FEB 2005	Modified text for grounding scheme and added figures for connector.

1 Introduction

An overview of the Level-1 trigger system [1] including the calorimeter trigger and the Central Trigger Processor (CTP) is shown in Figure 1. The calorimeter trigger consists of the Preprocessor (PP), the Cluster Processor (CP) and the Jet/Energy-sum Processor (JEP). The PP receives analogue signals from the electromagnetic and hadronic calorimeters, digitizes them and applies bunch crossing identification. The CP searches for electron/photon and hadron/tau clusters. The JEP searches for jets and calculates the missing E_T and total E_T values. The results of the CP and JEP are sent to the CTP which combines them with the trigger information from the muon trigger and forms the overall Level-1 trigger decision.

Figure 1: Overview of the Level-1 Trigger System



The Common Merger Modules (CMMs) [2] of the CP send multiplicity information on electron/photon clusters and on tau/hadron clusters, which can also be programmed to be electron/photon clusters, to the CTP input module (CTP_IN) [3]. The CMMs of the JEP send multiplicity information on jet and forward jet clusters, as well as energy information on total E_T, missing E_T and jet E_T sum to the CTP. The trigger information is sent as parallel trigger signals synchronous with the 40 MHz bunch crossing frequency of the LHC.

From the point of view of the CTP, the calorimeter trigger is also treated like a sub-detector. In addition to the trigger information, the calorimeter trigger and the CTP, interface also at the following levels:

- The calorimeter trigger receives Timing, Trigger and Control (TTC) signals sent by the CTP.
- The calorimeter trigger provides a 3-bit calibration request and a ROD_BUSY signal to the CTP.
- The calorimeter trigger and the CTP use the ATLAS online system for configuration and run control.

2 Physical Links

The CERN Level-1 team will take the responsibility of manufacturing the assembled cables between the Level-1 calorimeter trigger and the CTP. The cables between the different Level-1 calorimeter trigger CMMs will be included in the manufacturing at the cost of the Level-1 calorimeter trigger collaboration. Number and lengths of the additional cables need to be communicated to the CERN Level-1 team.

2.1 Cable

Five 34-pair cables carry the trigger signals from the CP and from the JEP to the CTP. Two cables are connected from the CP and three from the JEP. The CP and the JEP are located in USA15 on floor level 2 directly on top of the CTP which is located on floor level 1. The five cables pass through a hole in the floor between the two levels. The length of the cables is about 10 m.

The type of cable will be a round cable shielded with twisted pairs and global screen. It will have low skew and a characteristic impedance of about 100 Ω. The type of cable will be conform to the CERN standard IS 23. Such a cable is being standardized at the moment for purchase from the CERN stores.

2.2 Connector

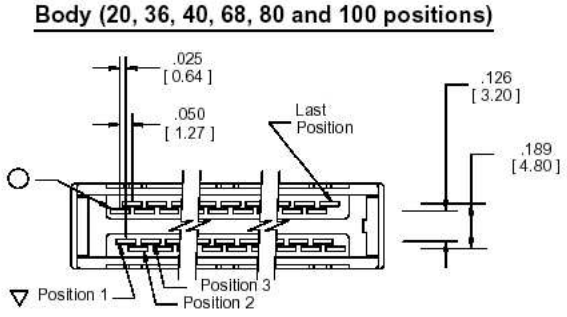
The connectors at both ends of the cable use contacts of type “bellows” or “ribbon”. The plug is on the cable and the receptacle or socket on the board. Table 1 summarizes the part numbers of the connector type to be used.

Table 1: Connector Types for the Physical Link

Manufacturer	Series	Cable plug	Board receptacle (right-angle tail)
preferred:			
3M	MDR	10168-6000EC	10268-55X3XX

The connectors of series MDR from manufacturer 3M [4] are not available from the CERN stores but will be ordered from 3M directly. The pin-out of the connector is defined in Table 4.

Figure 2: Cable Plug



The cable plug, the on-board receptacle and the layout for the on-board receptacle are detailed in figures 2, 3 and 4.

Figure 3: On-board Receptacle

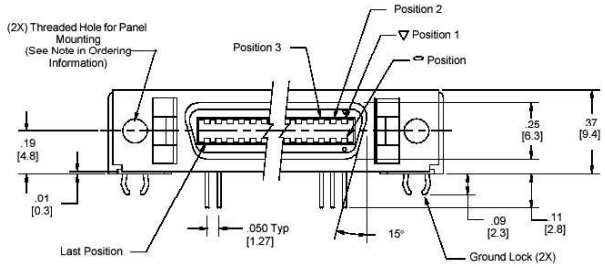
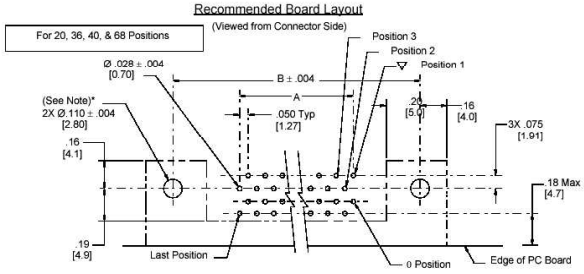


Figure 4: Layout for On-board Receptacle



2.3 Signalling and Logic

The trigger signals on the cables use Low-voltage Differential Signalling (LVDS) with 100 Ω termination at the end of the CTP. Positive logic will be used, i.e. the more positive level is interpreted as “1”, the less positive level as “0”.

2.4 Grounding

The global screen of the cable is connected to the metal shroud of the cable plug. The metal shroud of the receptacle is connected through its two fixing points, two metallized holes and wire straps to the ground of the module. Care should be taken that the metal shroud of the connector does not touch the front panel. The scheme used in the CTP_IN is shown on page 7 of the CTP_IN schematics [5]. If necessary, the wire straps can be replaced by other network coupling.

3 Signals

Each of the five cables has 31 pairs connected to trigger signals, one pair connected to clock signal, one pair connected to parity signal, and one pair connected to ground. The pin-out of each of the five cables is defined in Table 4. Pin 1 is on the lower right-hand side of the front panel as seen from the front. The positive signals are on the left-hand side and the negative signal on the right-hand side of the front panel as seen from the front. The pin-out used in the CTP_IN is shown in the CTP_IN front panel design [6].

3.1 Trigger Signals

The 31 trigger signals on each cable are currently not all used and some of them are available for future expansion. The five cables carry the trigger signals listed in Table .

Table 2: Trigger Signals

Cable	Trigger signals
CP cable #1	24 pairs electron/photon trigger signals
CP cable #2	24 pairs programmable electron/photon or tau/hadron trigger signals
JEP cable #1	24 pairs jet trigger signals 4 pairs jet transverse energy sum signals
JEP cable #2	16 pairs forward jet trigger signals
JEP cable #3	4 pairs total transverse energy signals 8 pairs missing transverse energy signals

3.2 Clock Signal

The clock signal is the 40 MHz bunch crossing frequency as used by the CMMs. It is used for timing-in at the end of the CTP. All trigger signals and parity signal on one cable have a fixed and known phase with respect to the clock signal of that same cable. All trigger signals and parity signal of one cable have a skew of below 5 ns in the worst case at the receiving end (CTP).

3.3 Parity Signal

The parity signal carries the odd parity calculated over all 31 trigger signals. All unused trigger signals have fixed value “0”. The parity signal is used by the CTP to detect parity errors. The parity errors are counted and reported to the ATLAS run control system.

3.4 Ground Signal

The ground signal lines are connected through two metallized holes and wire straps to the ground of the module. The scheme used in the CTP_IN is shown on page 7 of the CTP_IN schematics [5]. If necessary, the wire straps can be replaced by other network coupling.

4 Data Format

Each pair of a trigger signal corresponds to one bit. The trigger signals are grouped in number of bits. Each trigger signal group corresponds to a trigger algorithm. Two different types of trigger signal groups exist: the multiplicity type and the energy type.

For the multiplicity type the trigger signal group contains the number of objects found by the trigger algorithm. The least significant bit is the one with the lowest signal number and the most significant bit is the one with the highest signal number. If the number of objects exceeds the value that can be represented by the trigger signal group then the biggest value is sent.

For the energy type the trigger signal group contains one bit for each energy threshold. The least significant bit corresponds to the lowest energy and the most significant bit corresponds to the highest energy.

Table 3 lists the different classes of trigger signal groups, their symbolic name, their type, their width in number of bits, the number of trigger signal groups available in that class and the total number of trigger signals.

Table 3: Trigger Signal Groups

Class	Symbol	Type	Width [bit]	Number	Total
Electron/photon trigger	EM	multiplicity	3	8	24
Electron/photon or tau/hadron trigger	EM/TH	multiplicity	3	8	24
Jet trigger	J	multiplicity	3	8	24
Jet transverse energy sum	JE	energy	4	1	4
Forward jet trigger	FJ	multiplicity	2	2×4	16
Total transverse energy	TE	energy	4	1	4
Missing transverse energy	XE	energy	8	1	8
total					104

It should be noted that the number of multiplicity-type trigger signal groups and their widths can change in the future. This will allow to accommodate more trigger algorithms with smaller maximum multiplicities, e.g. instead of eight jet triggers using three bits each there could be twelve jet triggers using two bits each. The total number of trigger signals will stay the same.

Table 4 lists all trigger signals and defines the pin-out of the cables from the CP and from the JEP to the CTP using the symbolic names introduced. In addition, *CLK* is used for the clock signal, *PAR* for the parity signal and *GND* for the ground. The signal pair numbering uses the numbering of the pins on the connector. “neg” refers to the negative, and “pos” the positive part of the LVDS signals.

In addition, on the CTP_IN module, pins 69 and 70 for the connector screen are connected to strips which in turn can be connected to the ground o the CTP_IN module.

Table 4: Pin-out of Trigger Signals, Clock, Parity and Ground

Signal pairs	CP cable #1	CP cable #2	JEP cable #1	JEP cable #2	JEP cable #3
1 neg., 35 pos.	EM0 [0]	EM8 / TH0 [0]	J0 [0]	FJ0 [0]	TE [0]
2 neg., 36 pos.	EM0 [1]	EM8 / TH0 [1]	J0 [1]	FJ0 [1]	TE [1]
3 neg., 37 pos.	EM0 [2]	EM8 / TH0 [2]	J0 [2]	FJ1 [0]	TE [2]
4 neg., 38 pos.	EM1 [0]	EM9 / TH1 [0]	J1 [0]	FJ1 [1]	TE [3]
5 neg., 39 pos.	EM1 [1]	EM9 / TH1 [1]	J1 [1]	FJ2 [0]	XE [0]
6 neg., 40 pos.	EM1 [2]	EM9 / TH1 [2]	J1 [2]	FJ2 [1]	XE [1]
7 neg., 41 pos.	EM2 [0]	EM10 / TH2 [0]	J2 [0]	FJ3 [0]	XE [2]
8 neg., 42 pos.	EM2 [1]	EM10 / TH2 [1]	J2 [1]	FJ3 [1]	XE [3]
9 neg., 43 pos.	EM2 [2]	EM10 / TH2 [2]	J2 [2]	FJ4 [0]	XE [4]
10 neg., 44 pos.	EM3 [0]	EM11 / TH3 [0]	J3 [0]	FJ4 [1]	XE [5]
11 neg., 45 pos.	EM3 [1]	EM11 / TH3 [1]	J3 [1]	FJ5 [0]	XE [6]
12 neg., 46 pos.	EM3 [2]	EM11 / TH3 [2]	J3 [2]	FJ5 [1]	XE [7]
13 neg., 47 pos.	EM4 [0]	EM12 / TH4 [0]	J4 [0]	FJ6 [0]	reserved
14 neg., 48 pos.	EM4 [1]	EM12 / TH4 [1]	J4 [1]	FJ6 [1]	reserved
15 neg., 49 pos.	EM4 [2]	EM12 / TH4 [2]	J4 [2]	FJ7 [0]	reserved
16 neg., 50 pos.	EM5 [0]	EM13 / TH5 [0]	J5 [0]	FJ7 [1]	reserved
17 neg., 51 pos.	EM5 [1]	EM13 / TH5 [1]	J5 [1]	reserved	reserved
18 neg., 52 pos.	EM5 [2]	EM13 / TH5 [2]	J5 [2]	reserved	reserved
19 neg., 53 pos.	EM6 [0]	EM14 / TH6 [0]	J6 [0]	reserved	reserved
20 neg., 54 pos.	EM6 [1]	EM14 / TH6 [1]	J6 [1]	reserved	reserved
21 neg., 55 pos.	EM6 [2]	EM14 / TH6 [2]	J6 [2]	reserved	reserved
22 neg., 56 pos.	EM7 [0]	EM15 / TH7 [0]	J7 [0]	reserved	reserved
23 neg., 57 pos.	EM7 [1]	EM15 / TH7 [1]	J7 [1]	reserved	reserved
24 neg., 58 pos.	EM7 [2]	EM15 / TH7 [2]	J7 [2]	reserved	reserved
25 neg., 59 pos.	reserved	reserved	JE [0]	reserved	reserved
26 neg., 60 pos.	reserved	reserved	JE [1]	reserved	reserved
27 neg., 61 pos.	reserved	reserved	JE [2]	reserved	reserved
28 neg., 62 pos.	reserved	reserved	JE [3]	reserved	reserved
29 neg., 63 pos.	reserved	reserved	reserved	reserved	reserved
30 neg., 64 pos.	reserved	reserved	reserved	reserved	reserved
31 neg., 65 pos.	reserved	reserved	reserved	reserved	reserved
32 neg., 66 pos.	CLK	CLK	CLK	CLK	CLK
33 neg., 67 pos.	PAR	PAR	PAR	PAR	PAR
34 neg., 68 pos.	GND	GND	GND	GND	GND

5 Configuration Data

The configuration of the calorimeter trigger and the CTP is defined in the trigger menu [7]. The trigger menu defines the parameters used in the trigger algorithms of the calorimeter trigger (and the muon trigger), and their association to the trigger signal groups and the trigger items of the CTP. The trigger items are combinations of trigger conditions and the trigger conditions are conditions on the value of a trigger algorithm (which are also called trigger thresholds).

Thus, for the interface between the calorimeter trigger and the CTP the following information of the trigger menu is of particular interest:

- The association of trigger algorithms to trigger signal groups:
  E.g. the trigger algorithm defined by the trigger threshold “10 GeV, no isolation” can be associated to the trigger signal group “EM1”, i.e. signals[6..4] of CP cable #1.
- The association of energy thresholds to trigger signal groups:
  E.g. the energy thresholds “1600 GeV, 1400 GeV, 1200 GeV, 1000 GeV” of the total transverse energy algorithm are associated to bits TE[3..0] of the trigger signal group “TE”, i.e signals[4..1] of JEP cable #3.
- The association of trigger algorithms (and energies) to trigger items:
  E.g. the trigger item defined by “1EM1” is associated to the trigger signal group EM1 and requires a value of 1 or greater in this trigger signal group.

The information has to be available on-line to monitoring and calibration tasks, as well as off-line as part of the run-log information.

References

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[7] R. Spiwoks, Data Acquisition of the ATLAS Level-1 Central Trigger Processor, ATLAS EDMS Note ATL-DA-ES-0011, January 2004.